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SOIL NUTRIENTS STATUS AND CROPPING SYSTEM IN PLASTIC HOUSE CONDITION OF CHANDRAGIRI MUNICIPALITY KATHMANDU

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ABSTRACT

Soil nutrients are essential for plant growth, crop production, and sustainable agricultural development. In recent years plastic house is going popular around peri-urban areas of Nepal, including Chandragiri municipality of Kathmandu district. The research report covered the experience, learning and contribution on nutrient status and cropping system of plastic house of Chandragiri municipality of Kathmandu district. The main goal of the research was to access the nutrient status as well as other farm activities of the farmers to maintain soil fertility and enhance the crop yield for the sustainable agriculture. The research involved different activities like survey, interview and soil sampling. Total 50 plastic houses were visited randomly to achieve the goal and 20 samples out of 50 samples were randomly selected for the laboratory analysis to find out the status of nitrogen (N), phosphorus (P), potassium (P), Zinc (Zn) and Boron (B). The data collected from the interview related to the farm activities involved all 50 farms. The data was analyzed with the help of Microsoft excel and SPSS (version 25). The observed data revealed a range of soil nutrient concentrations, with varying levels of consistency across different variables. Nitrogen showed relatively stable concentrations with low variability. Available Phosphorus and Potassium showed wider fluctuations. Zinc also showed moderate variability. Boron contained the highest variability among the variables, reflecting significant inconsistency in its concentration levels across the samples. According to the survey data, the highly cultivated crop was found to be tomato and its average production was 53.3T/ha which concluded that plastic house farming in Chandragiri has high potential to produce all kind of the vegetable crops and improve their livelihoods if their obstacles such as limited investment, small landholding, lack of subsidies and market facilities are addressed.

Keywords: Cropping Systems, fertilizers, soil fertility, soil nutrient status, subsidies

INTRODUCTION

Nepal is characterized by diverse topography and climatic variations. From the fertile plains of Terai to the rocky terrain of the Himalayas the nation's agricultural productivity is deeply linked to its soil health (Ojha and Panday, 2021). However, the complex interaction of geological, climatic and anthropogenic factors increases the need for detailed examination of micronutrients (Shrestha, 2020). In the present condition, conventional rice-wheat rotations are increasingly replacing the diversified food crop production system with high- value vegetable crops across Nepal. Such systems are likely to enhance the demand for the micro- nutrients, such as boron (B) and Zinc (Zn), which are widely deficient throughout the country (Shrestha, 2021). Following the rice-wheat cropping system, maize-wheat is the second most important cropping system in Nepal, as well as the most prominent cropping system in mid-hills. In peri-urban areas, high value vegetable crops are replacing the cereal crops (Shrestha, 2021). Also, the plastic tunnel technology has become an important alternative technology for year-round crop production and is gaining popularity among farmers in the peri- urban areas of Kathmandu (Gautam, 2019).

According to Bhandari et al. (2016), Nepal has comparative advantages in tomato crop production, as evidenced by year-round production enabled by favorable agro-climatic conditions, an established distribution network, and rising demand. There is considerable potential for increasing tomato area and productivity through the use of appropriate technology. Tomatoes, being a labor-intensive crop, offer great potential for job creation in the country. Activities, such as transplanting, weeding, and harvesting are mostly accomplished manually by women.

While extensive research exists on soil nutrients and cropping systems, this study also examines the use of plastic tunnels in Chandragiri village aiming to address the gap and provide valuable insights for improving agricultural practices.

MATERIALS AND METHODS

Study area

The study was carried out in Chandragiri municipality, Kathmandu, Nepal. It is located at 27˚41' 25" N and 85˚ 13' 13" E. There are total 15 wards in this municipality. Macchegaun, Matatirtha, Bosigaun, Dhaulagiri, Naikap, Thankot and Gurjudhara was covered for the research. The soils are relatively fertile sandy and silty alluvial with some deposit of peat mare (diatomaceous clay). The climate of the study area is subtropical to temperate type. The warm season lasts from April to October and the cold season from December to February. The maximum and minimum average monthly temperature was reported to be in the months of June (28.9 ˚C) and January (18.3˚C) respectively. The highest (341.8 mm) average monthly rainfall was reported to occur in the month of July whereas the lowest (5.5 mm) average monthly rainfall occurred in the month of November (LLRC, 2016).

Sample size and data collection

The list of small farmers and large farmers were used as a sampling framework. 50 farms were randomly chosen from various locations within Chandragiri Municipality for this study. Farmers from all selected farms were interviewed using a pre-tested semi- structured questionnaire to collect primary information on agronomic practices, farm management, and production activities.

For soil analysis, 50 soil samples were collected from the surveyed farms and out of them 20 soil samples were selected randomly to ensure the representation from different parts of the municipality, with at least two samples taken from each area. The collected soil samples were analyzed in the soil testing laboratory to determine important soil properties, including soil pH, nitrogen (N), phosphorus (P), potassium (K), Zinc (Zn) and Boron (B). In addition to the primary data, secondary information was obtained from articles, journals, reports, websites and other relevant publications to support the findings of the study.

Statistical analysis

Data collected from the 50 surveyed farms were organized, coded, and summarized before being analyzed using descriptive statistical methods. The results obtained from the 20 soil samples were used to evaluate the soil nutrient condition of the study area. All statistical computations and data processing were carried out using Microsoft Excel and SPSS (version 25).

RESULTS and DISCUSSION

Soil nutrient status

The analysis of soil samples collected from plastic houses of Chandragiri Municipality revealed significant variation in nutrient status among the sampled farms. Nitrogen content ranged from low to moderate, indicating relatively stable distribution across samples. Available phosphorus showed considerable variation with some farms exhibiting higher concentrations. Potassium levels were generally adequate but varied among locations. Micronutrients such as Zn demonstrated moderate variability, whereas boron showed comparatively higher fluctuation across the sample sites. Overall, the results indicate considerable spatial variation in both macro-nutrients (Nitrogen, Phosphorus, and Potassium) and micro-nutrients (Zinc and Boron) across the plastic house of Chandragiri. While most major nutrients were found in moderate to adequate ranges, boron levels were comparatively low in several farms, suggesting possible micronutrient imbalance in some locations (Table 1).

Nitrogen Levels

Chandragiri's soil samples had a mean nitrogen concentration of 0.238% and a standard deviation (SD) of 0.754%. Nitrogen level showed moderate variation with a CV of 0.32 %

that indicates some variability around the mean. The nitrogen content ranged from 1.40 to 0.14 to 0.43% (Table 1). The narrow range and comparatively low mean suggests that nitrogen levels are often inadequate. For plants to flourish, nitrogen is necessary because it affects activities like protein synthesis and photosynthesis (Hassan et al., 2022). The low levels point to possible nitrogen shortage-related restrictions on crop productivity. This shortage may be caused by a lack of nitrogen-fixing bacteria, poor soil organic matter content, and ineffective fertilization techniques. It is advised to raise nitrogen levels by applying right dose of fertilizers and organic amendments (Pandit et al., 2022).

Table1. Soil Status of nutrients in the plastic house of Chandragiri

Farm No.	Sample Id	Nitrogen (mg^{-1})	Available Phosphorus (μgg^{-1})	Available Potassium (μgg^{-1})	Zinc (μgg^{-1})	Boron (μgg^{-1})
1	Machhegaun	0.227	81.74	121.72	4.88	0.17
2	Machhegaun	0.307	167.43	72.66	5.69	0.35
3	Machhegaun	0.434	219.12	100.21	2.52	0.52
4	Satungal	0.285	393.94	171.11	14.94	<0.10
5	Satungal	0.230	119.42	44.66	2.17	<0.10
6	Satungal	0.187	71.90	98.05	3.60	0.23
7	Satungal	0.179	135.41	170.96	2.06	0.35
8	Satungal	0.277	86.66	76.81	3.99	<0.10
9	Bosigaun	0.173	87.40	40.97	11.38	<0.10
10	Bosigaun	0.214	64.99	104.95	3.30	<0.10
11	Naikap	0.191	194.51	58.15	2.80	<0.10
12	Naikap	0.250	100.95	54.03	1.88	<0.10
133	Dhaulagiri	0.319	445.65	385.20	6.88	<0.10
14	Dhaulagiri	0.237	258.53	290.04	5.76	<0.10
15	Thankot	0.357	96.02	79.44	5.81	<0.10
16	Thankot	0.179	142.80	60.00	7.20	<.0.10
17	Thankot	0.140	105.87	16.05	7.45	0.35
18	Dahachok	0.162	073.87	40.50	3.90	<0.10
19	Matatirtha	0.187	103.41	42.92	3.17	0.14
20	Matatirtha	0.161	66.96	20.96	10.39	<0.10
Mean		0.238	150.83	102.47	5.4885	0.11515
SD		0.750	106.37	92.26	3.46178	0.15581
CV		31.71%	70.52%	90.04%	63.07%	102.84

Available Phosphorus

Significant variation can be seen in the phosphorus levels in the soil samples from Chandragiri which ranged from 64.99 to 445.65kg/ha, with a mean of 150.83kg/ha and an SD of 106.37kg/ha (Table 1). This indicates a wide range of values with some areas showing higher phosphorus level. For plants to transport energy, perform photosynthesis, and produce roots, phosphorus is essential (Fathi and Afra, 2023).
The high mean value implies that there is, on average, enough phosphorus available; nevertheless, the broad range shows that there is unequal distribution, with some locations having insufficient phosphorus. Variations in soil pH, organic matter concentration, and fertilizer application history could be the cause of this heterogeneity. By putting into practice site-specific phosphorus management techniques, such as routine soil testing and customized fertilizer, it will be possible to guarantee balanced phosphorus availability throughout the entire region, which will promote crop productivity.

Available Potassium

The soil samples from Chandragiri had varying potassium levels, with a mean value of 102.47kg/ha, SD of 92.26kg/ha (Table 1). The range of potassium levels was 16.05kg/ha to 385.20kg/ha. Potassium is necessary for a number of physiological processes in plants, such as photosynthesis, enzyme activation, and water management (Pandey and Mahiwal, 2020). The significant variation implies that although certain regions might have adequate potassium, others might not. The soil organic matter level, texture, and inheritance nutrient status could all be contributing causes to this. A focused strategy to potassium management, such as site-specific fertilization and soil amendments, is required to resolve these disparities. By doing this, it will be ensured that potassium levels in all locations are sufficient, encouraging healthy plant growth and raising agricultural yields.

Zinc Level

Soil samples from Chandragiri exhibited a moderate degree of diversity in their Zn contents; ranging from 1.88 to 14.94µg/g, with a mean of 5.4885µg/g, SD of 3.46178µg/g (Table 1). Plants need Zn for the synthesis of proteins and the operation of enzymes (Shrestha et al., 2020). While the moderate variability points to possible inadequacies in some places, the mean result showed that zinc levels are generally adequate. Reduced agricultural yields and stunted growth might result from zinc deficiency. The pH of the soil, the amount of organic matter, and the way zinc interacts with other nutrients are factors that affect Zn availability. To maintain sufficient Zn levels and prevent deficiencies, regular soil testing and proper zinc fertilization are advised. This will support the best possible health and production of plants (Vista and Shrestha, 2019).

Boron Level

Soil samples from Chandragiri had consistently low amounts of boron, with mean values of 0.1515µg/g, SD of 0.15581µg/g and ranges from 0.05 to 0.52µg/g (Table 1). Boron had highest variability suggesting extreme variation and potentially outlier values in the data set. For plants to construct their cell walls, develop their reproductive systems, and expand overall, they need boron (Shrestha et al., 2020). The consistently low levels point to a general B shortage, which may cause irregularities in the growth of flowers and fruits, poor root and shoot development, and decreased crop yields. To improve soil fertility and plant health, targeted boron fertilization is essential.

Fertilizer Application and Production of Tomato in Chandragiri

Overall, the data indicates that there is a heavy reliance on organic fertilizer to improve soil quality. Among the chemical fertilizers used, urea is most common, followed by DAP and potash. This suggests that while organic methods are the main priority, chemical fertilizers are still used in smaller amounts to support crop growth. The result (Table 2) explains the average fertilizer application and production of the 50 farms that were visited for survey in Chandragiri.

The data showed the mean application of the fertilizers (Table 2). According to (PMAMP, 2024) the recommended dose for hybrid tomato in controlled poly house is 200:180:80 NPK kg/ha and hybrid cauliflower is 200:120:100 NPK kg/ha while recommended dose of compost is 15000kg/ha for both crops. This shows the fertilizers applied by the farmers is higher than that of recommended dose but the average production of tomato is 53.3 T/ha and cauliflower is 5000kg/ha, which displays the information that fertilizers application above the threshold level do not increase the production instead production depends on the farm management practices too.

Table2. Mean fertilizer application by farmers in Chandragiri

Fertilizers	Mean Application of fertilizer (kgha^{-1})
Urea	277
DAP	204
Potash	165
FYM	24200
Zinc Sulphate	40
Borax powder	40

This result aligns with the observations of (Bhandari et al., 2016), who observed that Nepalese tomato growers frequently apply surplus nutrients under the mistaken belief that it will guarantee better harvests. In this study, the intensive use of Urea (277 kg/ha) and farm Yard Manure (24,200kg/ha) failed to produce a proportional rise in yield, indicating a clear nutrient disproportion. These findings reinforce the perspective of (Gautam, 2019), suggesting that crop productivity in plastic tunnels is driven more by precise environmental management than by the sheer quantity of additives. Ultimately, the current approach to soil fertility in the region appears wasteful; shifting toward data-driven, soil-test- base applications could lower expenses while preserving the long-term health of the land. To enhance agricultural productivity in Chandragiri Municipality, several strategic actions are proposed based on direct input from the farming community. Initially, a jointly effort between public and private entities is required to upgrade market infrastructure, provide financial support for inputs, and introduce modern farm equipment. Furthermore, moving away from general fertilizer use towards precise, site- specific nutrition plans derived from soil analysis is vital for ensuring crops obtain the correct nutrient balance. This tailored approach is a key to maximizing plant health and efficiency.

Major Crops Grown in Chandragiri

The bar diagram shows the distribution of cropping system in Chandragiri based on the main crops grown. According to the survey data; 34% of the farmers cultivate and produce tomato only following the cropping pattern: tomato-tomato-tomato; 60% of them produce cauliflower and tomato following the cropping pattern: tomato-cauliflower- tomato; 4% of them produce tomato and broccoli following the pattern tomato- broccoli-tomato and only 2% of the farmers produce tomato along with strawberry following the pattern tomato-tomato/ strawberry-tomato (Figure 1). This clearly shows that most commonly grown crop is tomato whereas least grown item is strawberry.

When comparing to the earlier research conducted in the Kathmandu valley, the 60% adoption of a cauliflower rotation signifies a favorable transition toward diversified cropping. The shift is more effective at disrupting pest life cycles and maintaining soil integrity than traditional monoculture methods. The scientific contribution of this research lies in demonstrating that while the transition to plastic house technology is high, further promotion of diverse crops such as broccoli and strawberry is essential to ensuring the long-term ecological and economical sustainability of these farming systems.

Use of Organic Fertilizers in plastic house

Different kinds of organic fertilizers are used in plastic farms of Chandragiri. Some are used singly and some in combined form. According to the available data, majority of farmers relay on FYM only which is 56% (Figure 2). Second majorly applied organic fertilizer is combination of FYM and poultry which is 8%. Combination of FYM and mustard oil cake and combination of FYM, compost and combination of FYM and vermicompost are applied by 6% of the farmers. 4% of the farmers apply poultry and combination of FYM and jhol maal whereas Combination of FYM and bone meal, combination of FYM, Vermicompost and mustard oil cake, combination of FYM, vermicompost and poultry manure and combination of oil cake and jaggery are applied by 2% of the farmer which is the least applied organic matters in Chandragiri.

The heavy reliance on FYM observed in this study aligns with the findings of (Bhandari et al., 2016), who noted that traditional organic matter remains the primary nutrient source for Nepalese vegetable growers. However, the low adoption rate of concentrated organic inputs like vermicompost and jhol maal suggests an opportunity for improvement in nutrient density. As highlighted by (Fathi amd Melidiniya, 2023), the synergy between diverse organic sources can significantly enhance microbial activity and plant growth resilience compared to single-source amendments. Furthermore, the scientific implication of these results suggests that while farmers are committed to organic practices, the high application volumes, as seen in earlier data may be a response to the lower nutrient concentration of raw FYM. This study supports the economic perspectives of (Gautam, 2019), suggesting that transitioning toward higher-quality organic combinations, such as FYM enriched with mustard oil cake or poultry manure, could optimize yield efficiency in intensive plastic tunnel environments. Promoting these diversified organic strategies is essential for the ling-term ecological sustainability of the Chandragiri agricultural sector.

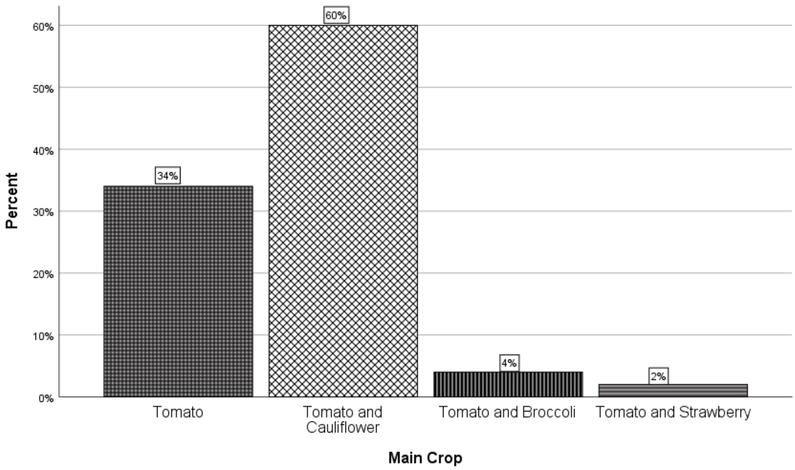

Figure 1. Distribution of farmers growing various crops in Chandragiri municipality under the plastic house

Use of Inorganic Fertilizers

The pie-chart shows the distribution of inorganic fertilizers in plastic farms of Chandragiri municipality. It is divided into three segments which are: Combination of urea, DAP along with potash which is applied by 90% of the farmers (Figure 3): combination of DAP with potash which is applied by 6% of the farmers and no use of any kinds of inorganic fertilizers which means 4% of the farmers do not apply any kinds of inorganic fertilizers. This distribution indicates a heavy reliance on combination of urea, DAP and potash as the primary source inorganic fertilizer. The survey results reveal an overwhelming dependence on a conventional mineral fertilizer regime, with 90% of respondents utilizing a tri-partial combination of Urea, DAP (Diammonium Phosphate), and Potash. This nearly universal reliance on synthetic inputs suggests a standardized approach to nutrient management among tomato growers in Chandragiri, likely driven by established market availability and historic yield responses. The preference for this specific chemical combination reflects broader agricultural trends across the Bagmati Province. However, as noted by (Bhandari et al., 2021), the continuous application of high- nitrogen fertilizers like urea, without adequate organic supplementation, often leads to long- term soil health degradation, including acidification and a decline in microbial activity. The concentrated use of DAP and Urea carries specific risks for protected plastic tunnels. To strengthen the scientific value of these results, considerations should be given to balance nutrient application, integrated nutrient management and soil testing services.

Tomato cultivars

The diagram displays the distribution of varieties of tomatoes in plastic farms of Chandragiri. Majorly cultivated breed is Srijana which is 62% which is more than half of all types used (figure 4). Mix breed of Srijana along with Samjana is second highly cultivated breed which is 14%. Combination of Sarita, Samjhana, Srijana and Karma77 is cultivated in 8% of the farms. Combination of Srijana and Sarbashrestha is cultivated by the 4% of the farms. The least cultivated breeds are Samjhana, combination of Srijana with Karma777, combination of Karma777, Sarita along with Sarba Shrestha and combination of Sarbashrestha and Karma777 which is 2%. The dominance of the Srijana hybrid in Chandragiri municipality indicates a clear farmer bias toward cultivars characterized by robust yields and resistance to soil-borne pathogens, especially bacterial wilt.

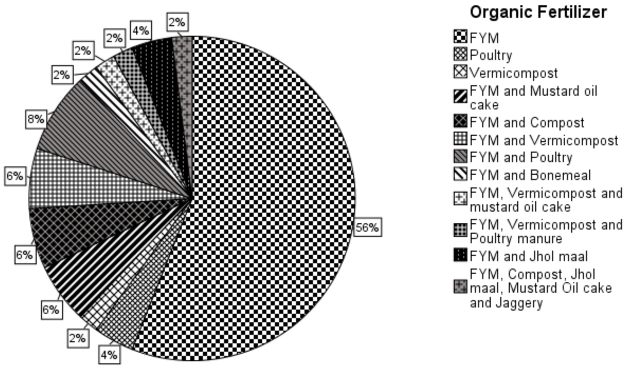

Figure 2. Different Kinds of organic fertilizers used by farmers in Chandragiri

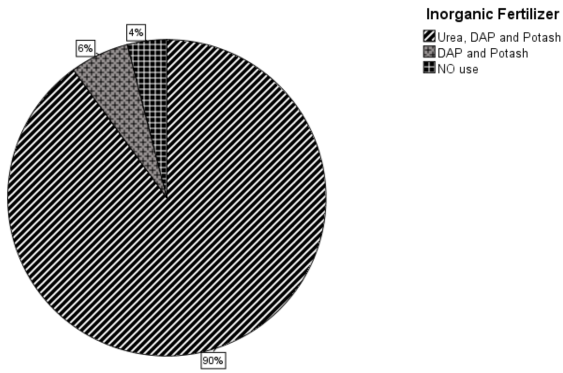

Figure 3. Different inorganic fertilizers used in Chandragiri Municipality?

This trend aligns with observations by (Gautam et al., 2024), who identified Srijana as the premier choice for Nepalese growers due to its extended productive window and post-harvest durability which are essential for maintaining fruit quality during transport to the Kathmandu valley markets.When considering Srijana and its blends, the total adoption exceeds 75%, signaling a significant lack of genetic diversity in local tomato production. While such uniformity ensures predictable market supply, it creates a precarious monoculture environment. Conversely, the marginal use of alternative cultivars such as Samjhana or karma777 (ranging from 2% to 4%) suggests that these varieties may suffer from limited commercial appeal or struggle to adopt to the specific temperature and humidity profiles found in Chandragiri's plastic tunnel systems.

Availability of input subsidies The bar graph reveals the distribution of subsidies especially inputs for the farm activities by the Prime Minister Agriculture Modernization Project (PMAMP) in Chandragiri. Majority of the farmers in Chandragiri were well known about the subsidies but they were not provided because of small land holding and non-registration of farms which is 68% whereas 10% of the farmers are unaware about any kind of subsidies as they were illiterate (figure 6). 14% of the farmers were getting powertiller, plastic and pipe. Only 2% of the farmers were provided by power tiller, plastic and pipe, other 2% were provided by pipe along with drum, also another 2% of the farmers got plastic with pipe and last 2% of the farmers got power tiller along with pipe. These subsidies were granted by PMAMP. The data indicates a significant gap between subsidy awareness and actual utilization within Chandragiri municipality. While a vast majority of the farming population is cognizant of the Prime Minister Agriculture Modernization Project (PMAMP) initiatives, a striking 68% remain unable to access these resources due to structural constraints, especially small land holding sizes and a lack of formal farm registration.

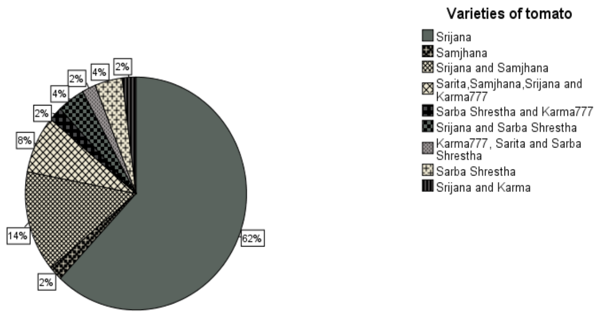

Figure 4. Major breeds of tomato cultivated in Chandragiri

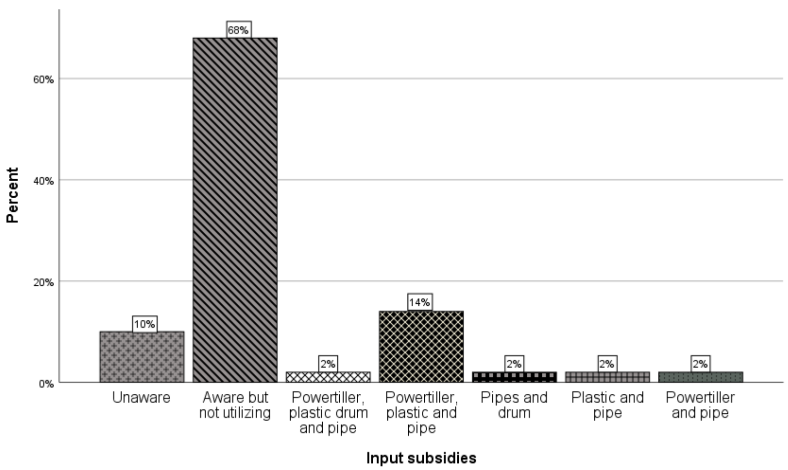

Figure 5. Utilization of subsidies provided by PMAMP

This disparity between knowledge and access resonates highly with the conclusions of (Adhikari et al., 2021), who highlighted that the administrative prerequisites of Nepalese agricultural frameworks frequently create unintended obstacles for smallholder cultivators. The mandatory institutional enrollment functions as a structural barrier, effectively excluding the most vulnerable producers from acquiring essential technological assets, such as protected cultivation structures and mechanized tillers, which are vital for enhancing productivity.

CONCLUSION

The results of this research highlight the pivotal impact of protected cultivation on agricultural modernization in Chandragiri Municipality. Although the 60% prevalence of tomato- cauliflower successions indicates a lucrative shift toward off-season vegetable production, comprehensive pedological evaluations reveal a marked disequilibrium in essential nutrient profiles. Analytical data showed a mean nitrogen concentration of 0.238%, coupled with significant fluctuations in potassium, phosphorus, and boron levels. Such variability suggests an imminent risk of either acute nutrient depletion or potential mineral phytotoxicity within specific farm sites.

Despite these heterogeneous soil profiles, producers continue to apply fertilizers at rates that substantially surpass recommended agronomic thresholds, specifically averaging 277kg/ha of Urea and 24,200kg/ha of Farm Yard Manure. The observation that mean tomato yields (53.3 t/ha) remain stagnant despite such intensive inputs confirms that existing fertilization strategies are mismatched with the actual physiological demands of the crop and the baseline soil status. Therefore, the future sustainability of plastic house enterprises in this region depends upon a transition from broad- spectrum nutrient applications to a precision- based management framework rooted in routine soil analysis.

RECOMMENDATIONS

To optimize agricultural output and ensure the sustainability of farming enterprises within Chandragiri Municipality, several evidence-based strategies are recommended. Initially, a fundamental shift from broad- spectrum fertilization to a precision- based nutrient management framework which is rooted in systematic, Site-specific soil diagnostics is vital. This calibrated approach is designed to provide crops with precise nutritional requirements, thereby mitigating the systematic inefficiencies associated with the current over-application of fertilizers. Additionally, local agricultural extension bodies should launch targeted outreach programs to educate the farming community on how to efficiently access existing subsidies for essential inputs like seeds and fertilizers. Finally, the implementation of a regulated price-support mechanism by the state is essential to insulate producers from the secure equitable financial compensation for their agricultural contributions.

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